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(54) **Emulsion fuel feeding apparatus and method**

Verfahren und Vorrichtung zur Zuführung von Brennstoffemulsion

Procédé et appareil d'alimentation en carburant émulsionné

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Description

This invention relates to an emulsion fuel feeding apparatus especially for use for a diesel engine. Further, the invention relates to a method to form a water-in fuel oil-emulsion.

It is generally known that NOx components in an exhaust gas can be reduced and an engine knock can be prevented by lowering the combustion temperature inside cylinders by feeding a fuel comprising an emulsion of a fuel oil and water to a Diesel engine. When, however, the engine is operated while the water content of the emulsion fuel is kept constant irrespective of the engine load, there occurs the problem that although the NOx components in the exhaust gas can effectively be reduced during a high speed high load operation, for example, the combustion temperature drastically drops and detrimental components such as HC and CO in the exhaust gas increase, on the contrary, during a low speed low load operation.

Various methods and apparatuses have been proposed as the apparatus for forming the emulsion of the fuel oil and water. For preparing such an emulsion it is already known (EP 0 392 545 A1) to use a rotationally symmetric vortex chamber in the form of a hollow pear having a tangential inlet and a tapering axial outlet, the vortex chamber being surrounded by a ring channel into which an oil inlet passage opens in tangential direction and which in turn is connected to the vortex chamber via tangential inlet slots. The water is jetted by a water jet nozzle into the ring channel or the vortex chamber. The tapering outlet of the vortex chamber opens via a stepped enlargement into the suction chamber of a radial-flow pump comprising a radial-flow pump impeller in a pump chamber and an emulsion outlet passage extending in parallel with the axis of the impeller and directing the prepared emulsion to the injection pump and into a recycling inlet passage, which in turn is tangentially opening into the ring channel. It is reached by the recycling of the emulsion into the vortex chamber and by the sudden enlargement at the outlet of the vortex chamber and by the change of direction of the flow at the exit of the radial-flow impeller, that an emulsion with an average droplet size of 2 to 4 micron are formed, whereby a fine and homogeneous emulsion results being well suitable for the operation of diesel engines.

By using an electromagnetic water injection nozzle the water content of the emulsion can be controlled in dependence on the operating state of the diesel engine. However, due to the recycling of the emulsion there is some delay until the desired water content of the emulsion is obtained. Therefore there is a demand to be able to readily and quickly change the water content of the emulsion in accordance with the engine load state.

By the invention the aforesaid problem is solved by an oil-water emulsion formation apparatus and a method as described in the claims.

Fig. 1 is a schematic view showing an embodiment of an emulsion fuel feeding apparatus.

Fig. 2 is a sectional view of the emulsion formation apparatus shown in Fig. 1.

Fig. 3 is a schematic sectional view of the metering unit shown in Fig. 1.

Fig. 4 is an explanatory wiew useful for explaining the operation of the metering unit shown in Fig. 1.

Fig. 5 is an explanatory view useful for explaining the operation of the metering unit shown in Fi 1.

An embodiment of the emulsion fuel feeding apparatus of the present invention will be explained with reference to Figs. 1 to 5.

Fig. 1 is a schematic view of the emulsion feeding apparatus as a whole. In this embodiment a plurality of emulsion formation apparatuses 100 are interposed between the fuel injection pump and each of the fuel injection nozzles of the cylinders, each emulsion formation apparatus 100 being fitted individually to the fuel injection nozzle 102 of the respective cylinder.

In Fig. 1, reference numeral 104 represents the fuel injection pump and reference numeral 106 represents a metering unit for jetting water which will be later described. The emulsion formation apparatus 100 can be connected to the fuel inlet portion of the fuel injection nozzle 102 without modifying the ordinary fuel injection nozzle 102. As can be understood from Fig. 1, the emulsion formation apparatus 100 has the function of mixing the high pressure fuel supplied from the fuel injection pump 104 to the fuel injection nozzle 102 with high pressure water supplied from the metering unit 106, forming the emulsion of the fuel oil and water, and jetting it into the cylinder from the respective injection nozzle.

Fig. 2 is a longitudinal sectional view of the emulsion formation apparatus 100. The emulsion formation apparatus 100 includes a pressure-resistant housing 111 capable of withstanding the jetting pressure of the fuel, and an inlet chamber such as a swirl chamber 112 which is defined inside the housing 111. The swirl chamber 112 has the shape of rotation symmetry and is shaped into a so-called "pear" shape having a tapered nozzle shape the diameter of which decreases progressively from the upper portion through an increased diameter portion in this embodiment. A lower nozzle outlet 114 of the swirl chamber 112 opens via a sharp edge 114a into a threaded bore 113 of a diameter substantially exceeding that of nozzle outlet 114. The fuel inlet of the fuel injection nozzle 102 is rigidly screwed into the threaded bore, so that the emulsion fuel leaving the swirl chamber 112 is supplied into the injection nozzle 102. The swirl chamber 112 is surrounded near the increased diameter portion thereof by a ring channel 115. A passage 117 formed inside the housing 111 and connected to the fuel injection pump 104 is opening into ring channel 115 in tangential direction thereof. Three ports 116 evenly distributed around the circumference of swirl chamber 112 are open to the wall surface of the swirl chamber 112 in the tangential direction near the increased diameter portion of the swirl chamber 112. In a modified embodiment

(not shown) the ring channel 115 may be omitted. In such an embodiment channel 117 would opening directly into the swirl chamber 112 approximately in tangential direction of the wall surface of the swirl chamber 112 via a sharp edge.

A nonreturn valve formed as a poppet valve 118 is normally biased in the valve closing direction by a spring 118a. The water injection port 120 is connected to the metering unit 106 through the water piping. When the pressure of water supplied from the metering unit 106 to the injection port 120 exceeds a predetermined value (e.g. 30 bars), the poppet valve 118 is pushed by the water pressure and opens the valve against the force of the spring 118a, so that water is jetted from the water injection port 120 into the swirl chamber 112. The poppet valve 118 has the valve body head shaped such that water can be sprayed uniformly in an umbrella shape into the swirl chamber 112.

In this embodiment, the water injection into the swirl chamber 112 is effected at an intermediate point between two successive high pressure fuel supply intervals and fuel injection intervals of the associated fuel injection nozzle 102 into the cylinder (at a point after 360° in terms of the crank angle after completion of the fuel injection in a four-cycle engine, for example) and at such a point at which the fuel pressure inside the swirl chamber 112 is dropped to e.g. 3 to 10 bar and the fuel injection nozzle 102 is closed. The water is injected in a dosed quantity into swirl chamber 112 under a pressure of e.g. 35 bars. The pressure increase effected by the water injection into the swirl chamber 112 is too low to open the injection nozzle 112. Fuel displaced by the injected water is returned through the fuel supply line to the injection pump 104 through a relief valve thereof (not shown, but orderly present at the injection pump for pressure relief in the oil supply lines at the end of the injection intervals) and is collected in a special container (not shown). The amount of injected water being at least three times smaller than the amount of fuel present in the supply line and in the swirl chamber, no water can reach the injection pump.

When the fuel injection timing is reached after water is injected into the swirl chamber 112, high pressure fuel is supplied from the fuel injection pump 104 into the swirl chamber 112 and flows into the fuel injection nozzle 102 from the nozzle outlet 114 below the swirl chamber 112. Since this fuel is injected into the swirl chamber 112 from the tangential direction, the content of the swirl chamber 112 is caused during the high pressure fuel supply interval to rotate with high speed. The injection nozzle opens under the high fuel pressure and a strong vortex flow is created inside the swirl chamber 112 during the injection period of the injection nozzle when the emulsion flows out of the swirl chamber 112 into the open injection nozzle of fuel injection nozzle 102. During flowing out of the swirling emulsion the pressure in the flow decreases in the tapering portion of the swirl chamber 112. The pressure in the flow is then increasing again after the flow has passed the sharp shearing edge 114a due to the sudden enlargement of the flow cross-section in bore 113 at the entry into the injection nozzle. Due to these events, fine particulation of the water particles atomized in advance into the swirl chamber 112 and their uniform mixing with the fuel are effected. Accordingly, an uniform emulsion of the fuel oil and water is supplied from the nozzle outlet 114 into the fuel injection nozzle 102 and is injected into the respective cylinder from the nozzle of the fuel injection nozzle 102.

Further, since the water injection nozzle 118 is designed as a poppet valve having an enlarged valve disk, the valve 118 is sealed under the effect of the high fuel injection pressure, so that the return spring of the valve can be designed for a small spring force.

As resulting from the foregoing description of the operation of the emulsion formation apparatus 100, the content of the swirl chamber is driven for rotation by the tangentially entering pressure oil only during the high pressure oil supply intervals, controlled by the fuel injection pump, and rotates idle in the time interval between two successive high pressure oil supply intervalls under a substantial reduced middle pressure. The water is injected in each of these time intervals of reduced pressure, so that the water supply intervals and the oil supply intervals alternate with eachother. The water-in-oil emulsion is prepared by the injection of water into the swirl chamber and is finished in a vortex out flow created during the displacement into the injection nozzle by the high pressure oil supplied by the fuel injection pump. Further, no recirculation of the formed emulsion into the swirl chamber is required, enabling in principle to individually adjust the water content of the fuel injected into the cylinder in each of the injection periods.

Next, the metering unit 106 (see Fig. 1) for supplying high pressure water to the emulsion formation apparatus of each cylinder will be explained. The metering unit 106 receives a water charging quantity signal in accordance with the engine combustion state from a water charging judgement/regulation circuit and supplies a predetermined quantity of water to the emulsion formation apparatus 100 of each cylinder at a predetermined timing.

In this embodiment, the metering unit 106 incorporates therein a high pressure water pump (not shown in the drawings) which is driven by the engine output shaft, sucks water from the water tank 108 and supplies it to each emulsion formation apparatus at a pressure of e. g. approximately 35 bars. The built-in high pressure water pump preferably has a capacity sufficiently greater than the maximum value of the water injection quantity (about three times the maximum charging quantity, for example), and excessive water is preferably returned into the water tank 108 from the high pressure water pump outlet through a recycling piping (not shown in the drawings).

Figs. 3 to 5 are schematic views showing the structure and operation principle of the metering unit 106.

As shown in Fig. 3, the metering unit 106 includes a cylindrical outer housing 121, a sleeve (inner housing) 123 pressed into and fixed to this outer housing 121 and a rotor 125 rotating inside the sleeve 123. In the outer housing 121 are disposed a water inlet port 121a from the high pressure water pump and water discharge ports 121c, 121d (the port positions for the 2-cylinder engine being shown in Figs 3 to 5) for the emulsion formation apparatus 100 for each cylinder. The sleeve 123 is provided with water inlet ports 123a, 123b communicating with water feed passage defined between the sleeve 123 and the outer housing and with discharge ports 123c, 123d communicating with discharge ports 121c, 121d of the outer housing 121. The rotor 125 is provided with a bore 125a at its center and ports 125c, 125d communicating with this bore 125a in the radial direction. The port 125c alternately communicates with the ports 123a, 123c of the sleeve when the rotor 125 rotates while the port 125d communicates alternately with the ports 123b, 123d of the sleeve when the rotor 125 rotates.

The ports 123a, 123c, the ports 123b, 123d and the ports 125c, 125d of the rotor are disposed at positions which are mutually symmetric at 180°.

The rotor 125 is synchronously driven at a speed of 1/2 of that of the crank shaft by the engine crank shaft through a toothed belt, or the like.

A piston 127 and a movable stopper 129 are slidably disposed inside the bore 125a of the rotor 125, and the position of the movable stopper 129 in the axial direction can be adjusted from outside by rotating a cam 110. A stationary stopper 125e is formed at the end portion inside the bore 125a opposite to the movable stopper 129.

In this embodiment, when the rotor 125 is rotated, the port 125c of the rotor 125 alternately communicates with the ports 123a, 123c and the port 125d of the rotor alternately communicates with the ports 123b, 123d of the sleeve, so that the piston 127 reciprocates inside the bore 125a and alternately discharges high pressure water from the discharge ports 123c (121c) and 123d (121d).

Hereinafter, this function will be explained with reference to Figs. 4 and 5.

First of all, when the rotor 125 rotates and the port 125c communicates with the port 123a of the sleeve as shown in Fig. 4, water from the high pressure pump flows from the port 123a into bore 125a at the left side of the piston 127 in the drawing. Therefore, the piston 127 is pushed to the right in the drawing. Under this state, the port 125d existing on the right side of the piston 127 communicates with the discharge port 123d of the sleeve 123. Accordingly, when the piston 127 moves to the right, water inside the bore 125a on the right side of the piston 127 is pushed by the piston 117 from the port 123d and flows out. Water that flows out from the port 123d is supplied to one of the emulsion formation apparatuses and the feed pressure of this water is substantially equal to the discharge pressure (approx. 35 bars) of the pressure of water acting on the left side of the piston 127, that is, the discharge pressure (approx. 35 bars) of the high pressure water pump. Discharge of water from the port 123d stops when the piston 127 moves to the right and strikes the stationary stopper 125e of the rotor 125. Next, when the rotor 125 further rotates and comes to the position shown in Fig. 5, the port 125d communicates with the inlet port 123b of the sleeve 123 and the port 125c communicates with the discharge port 123c. Accordingly, high pressure water flows to the right side of the piston 127 from the port 123b in the opposite way to Fig. 4 and pushes the piston 127 to the left. In consequence, water inside the bore 125a on the left side of the piston 117 is discharged from the port 123c into another emulsion formation apparatus. In this case, too, discharge of water from the port 123c stops when the piston 127 strikes the movable stopper 129. In this way, the piston 127 reciprocates between the stationary stopper 125e and the movable stopper 129 and feeds water in a quantity corresponding to its stroke into the emulsion formation apparatus of each cylinder.

As described above, the quantity of water (water charging quantity) supplied to each emulsion formation apparatus is determined by the stroke of reciprocation of the piston 127 of the metering unit 106, that is, the gap between the stationary stopper 125e and the movable stopper 129. In this embodiment, the position of the movable stopper 129 can be adjusted from outside by rotating the cam 110. Therefore, if a suitable actuator such as a stepper motor is disposed and the cam 110 is rotated to the water charging quantity set by the water charging quantity judgement/regulation circuit, it becomes possible to regulate the water quantity to be fed to the emulsion formation apparatus of each cylinder and to adjust the water content of the emulsion fuel in accordance with the combustion condition of the engine.

By the way, Figs. 4 and 5 show the cam position when the stroke is maximal (the maximum water charging quantity) and Fig. 3 shows the cam position when the stroke is zero (the stop of water charging).

Though Figs. 3 through 5 explain the metering unit for a two-cylinder engine, this metering unit can easily be adapted to 4-, 6-, 8- and 12-cylinder engines by changing the numbers of the ports of the rotor 125 and sleeve 123. In the case of a six-cylinder engine, for example, six ports are disposed at angles of 60° to the axis of rotation of the rotor. On the other hand, though an adjustment of the cam position of the metering unit by an electronically controlled stepper motor or other suitable actuater is preferred, it is also possible to control the cam position mechanically in accordance with the adjustment of the fuel injection pump 104 by coupling the cam to the adjusting rod of the fuel injection pump, as shown by the dashed line in Fig. 1.

In the embodiments above, the water charging timing to the emulsion formation apparatus of each cylinder

is adjusted to a predetermined crank angle by synchroneously driving the rotor 125 from the crank shaft by the use of this metering unit. However, when the water content of the emulsion fuel is individually changed in accordance with the combustion state of each cylinder, water from the high pressure punk is individually fed to each emulsion formation apparatus (the swirl chamber 112 shown in Fig. 2) through a solenoid valve disposed for each cylinder without using the metering unit. For example, it is possible to individually change the water content of the emulsion fuel to be fed to each cylinder by detecting the combustion pressure of each cylinder by a pressure sensor to determine the water charging quantity, sensing the water charging quantity signal to the solenoid controller, and regulating the opening/closing time controlled by this solenoid controller.

Claims

1. An oil-water injection system for a cylinder of a Diesel engine the system comprising

   a fuel injection nozzle (102) suitable to be connected to a cylinder of a Diesel engine, the fuel injection nozzle comprising an inlet portion;
   a fuel injection pump (104) having an oil outlet;
   a swirl chamber (112) having the shape of rotation symmetry;
   an oil inlet passage (117) opening into the swirl chamber in a tangential direction;
   a water jet nozzle (118, 118a) disposed at one of the ends of the swirl chamber in an axial direction; and
   an emulsion outlet passage (114) formed at the other end of the swirl chamber in the axial direction,

   characterised in that

   the swirl chamber is disposed at the inlet portion of the fuel injection nozzle;
   the oil inlet passage is connected to the oil outlet of the fuel injection pump; and
   the emulsion outlet passage connects the swirl chamber to the fuel injection nozzle inlet portion.

2. An oil-water emulsion formation apparatus according to claim 1, wherein the swirl chamber (112) tapers towards the emulsion outlet passage (114) and the emulsion outlet passage (114) is formed with a stepped enlargement (114a) at the outlet end of the swirl chamber (112).

3. An oil-water emulsion formation apparatus according to claims 1 or 2, wherein the water jet nozzle (118) is designed as a poppet valve.

4. A method of forming a water-in-oil emulsion at a Diesel engine which engine comprises a fuel injection nozzle (102) for an engine cylinder, the injection nozzle having an inlet portion; a fuel injection pump (104); and a swirl chamber (112) disposed between the outlet of the fuel injection pump and the inlet portion of the fuel injection nozzle, the method comprising the steps of:

   injecting water in a predeterminedly dosed quantity into Diesel oil present in the swirl chamber to form an oil-water emulsion, the water injection being performed at an intermediate point between fuel injection intervals of the fuel injection nozzle (102) whereby fuel injections are started by the supply of high pressure fuel from the fuel injection pump (104) to the swirl chamber (112); and
   rotating the oil-water-emulsion in the swirl chamber (112) and holding the oil-water-emulsion in rotation during the injection interval of the fuel injection nozzle by tangentially introducing Diesel oil fed from the fuel injection pump under high pressure into the swirl chamber, while supplying the rotating oil-water-emulsion into the fuel injection nozzle (102).

Patentansprüche

1. Öl-Wasser-Einspritzsystem für einen Zylinder eines Dieselmotors, mit

   einer Kraftstoffeinspritzdüse (102), die an einen Zylinder eines Dieselmotors anschließbar ist, wobei die Kraftstoffeinspritzdüse einen Einlaßabschnitt aufweist;
   einer Kraftstoffeinspritzpumpe (104), die einen Ölauslaß aufweist;
   einer Wirbelkammer (112) mit einer rotationssymmetrischen Form;
   einer Öleinlaßöffnung (117), die in die Wirbelkammer in tangentialer Richtung mündet;
   einer Wasserspritzdüse (118, 118a), die an einem der Enden der Wirbelkammer in Axialrichtung angeordnet ist; und
   einer Emulsionsauslaßöffnung (114), die an dem anderen Ende der Wirbelkammer in Axialrichtung ausgebildet ist,

   dadurch gekennzeichnet, daß

   die Wirbelkammer an dem Einlaßabschnitt der Kraftstoffeinspritzdüse angeordnet ist;
   die Öleinlaßöffnung mit dem Ölauslaß der Kraftstoffeinspritzpumpe verbunden ist; und
   die Emulsionsauslaßöffnung die Wirbelkammer mit dem Einlaßabschnitt der Kraftstoffein-

spritzdüse verbindet.

2. Vorrichtung zum Bilden einer Öl-Wasser-Emulsion nach Anspruch 1, wobei sich die Wirbelkammer (112) zur Emulsionsauslaßöffnung (114) hin verjüngt und die Emulsionsauslaßöffnung (114) mit einer stufenförmigen Aufweitung (114a) an dem Auslaßende der Wirbelkammer (112) versehen ist.

3. Vorrichtung zum Bilden einer Öl-Wasser-Emulsion nach Anspruch 1 oder 2, wobei die Wasserspritzdüse (118) als Tellerventil gestaltet ist.

4. Verfahren zum Bilden einer Wasser-Öl-Emulsion in einem Dieselmotor, welcher Motor eine Kraftstoffdüse (102) für einen Zylinder des Motors, wobei die Einspritzdüse einen Einlaßabschnitt aufweist; eine Kraftstoffeinspritzpumpe (104); und eine Wirbelkammer (112) aufweist, die zwischen dem Auslaß der Kraftstoffeinspritzpumpe und dem Einlaßabschnitt der Kraftstoffeinspritzdüse angeordnet ist, wobei das Verfahren folgende Schritte aufweist:

Einspritzen von Wasser in einer vorbestimmten dosierten Menge in Dieselöl, das in der Wirbelkammer vorhanden ist, um eine Öl-Wasser-Emulsion zu bilden, wobei die Wassereinspritzung an einem Zwischenpunkt zwischen Kraftstoffeinspritzintervallen der Kraftstoffeinspritzdüse (102) durchgeführt wird, wobei Kraftstoffeinspritzungen durch die Zuführung unter Hochdruck stehenden Kraftstoffs von der Kraftstoffeinspritzpumpe (104) zur Wirbelkammer (112) hin ausgelöst werden; und
Rotieren der Öl-Wasser-Emulsion in der Wirbelkammer (112) und Halten der Öl-Wasser-Emulsion in Rotation während des Einspritzintervalls der Kraftstoffeinspritzdüse durch tangentiales Einspritzen von Dieselöl, das von der Kraftstoffeinspritzpumpe unter Hochdruck in die Wirbelkammer geführt wird, wobei die rotierende Öl-Wasser-Emulsion der Kraftstoffeinspritzdüse (102) zugeführt wird.

Revendications

1. Dispositif d'injection fioul - eau pour un cylindre d'un moteur diesel, le dispositif comprenant

un gicleur d'injection de carburant (102) adapté pour être raccordé à un cylindre d'un moteur diesel, le gicleur d'injection de carburant comprenant une partie d'admission;
une pompe d'injection de carburant (104) ayant une sortie de fioul;
une chambre de tourbillonnement (112) ayant une forme à symétrie de rotation;
un passage d'admission de fioul (117) débouchant dans la chambre de tourbillonnement dans une direction tangentielle;
un gicleur de jet d'eau (118, 118a) disposé à une des extrémités de la chambre de tourbillonnement dans une direction axiale; et
un passage de sortie d'émulsion (114) formé à l'autre extrémité de la chambre de tourbillonnement dans la direction axiale,

caractérisé en ce que

la chambre de tourbillonnement est disposée à la partie d'admission du gicleur d'injection de carburant;
le passage d'admission de fioul est raccordé à la sortie de fioul de la pompe d'injection de carburant; et
le passage de sortie d'émulsion raccorde la chambre de tourbillonnement à la partie d'admission du gicleur d'injection de carburant.

2. Dispositif de formation d'une émulsion fioul - eau selon la revendication 1, dans lequel la chambre de tourbillonnement (112) va en se rétrécissant vers le passage de sortie d'émulsion (114) et le passage de sortie d'émulsion (114) est formé avec un élargissement à gradins (114a) à l'extrémité de sortie de la chambre de tourbillonnement (112).

3. Dispositif de formation d'une émulsion fioul - eau selon les revendications 1 ou 2, dans lequel le gicleur de jet d'eau (118) est une soupape à champignon.

4. Procédé pour former une émulsion d'eau - dans - du fioul pour un moteur diesel, lequel moteur comprend un gicleur d'injection de carburant (102) pour un cylindre de moteur, le gicleur d'injection ayant une partie d'admission; une pompe d'injection de carburant (104); et une chambre de tourbillonnement (112) disposée entre la sortie de la pompe d'injection de carburant et la partie d'admission du gicleur d'injection de carburant, le procédé comprenant les opérations consistant à :

injecter une quantité dosée de façon prédéterminée d'eau dans le fioul diesel présent dans la chambre de tourbillonnement pour former une émulsion fioul - eau, l'injection de l'eau étant effectuée en un point intermédiaire entre les intervalles d'injection de carburant du gicleur d'injection de carburant (102), des injections de carburant étant déclenchées par l'alimentation de carburant sous pression élevée de la pompe d'injection de carburant (104) à la chambre de tourbillonnement (112); et
faire tourner l'émulsion fioul - eau dans la

chambre de tourbillonnement (112) et maintenir l'émulsion fioul - eau en rotation pendant l'intervalle d'injection du gicleur d'injection de carburant en introduisant tangentiellement le fioul diesel alimenté de la pompe d'injection de carburant sous pression élevée dans la chambre de tourbillonnement, tout en alimentant l'émulsion fioul - eau en rotation dans le gicleur d'injection de carburant (102).

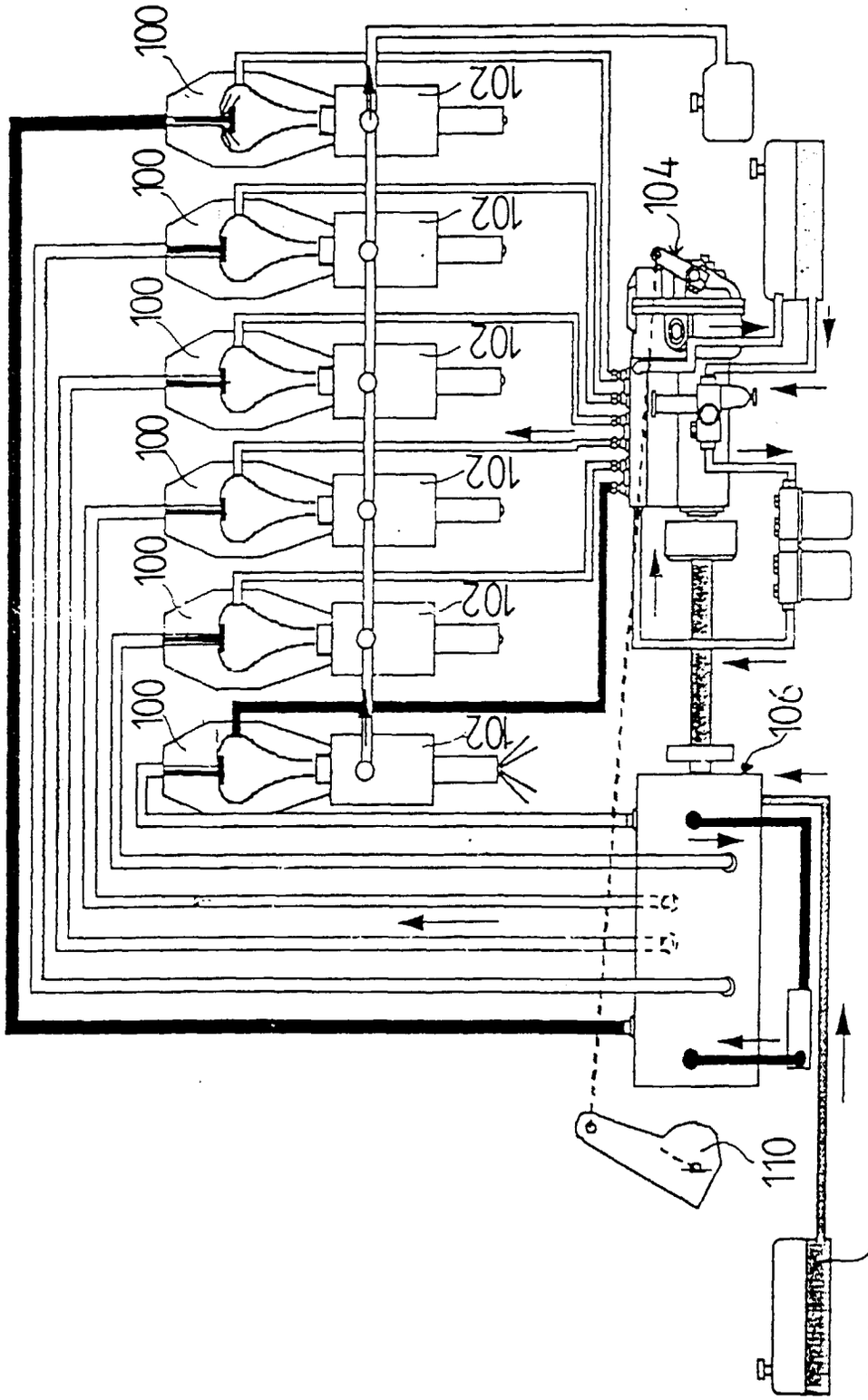


Fig. 1

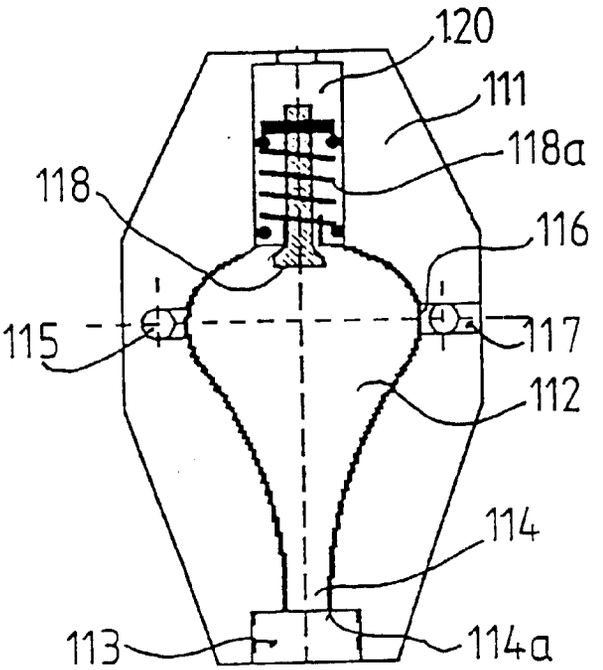

120
111
118a
118
116
115
117
112
114
113
114a

Fig. 2

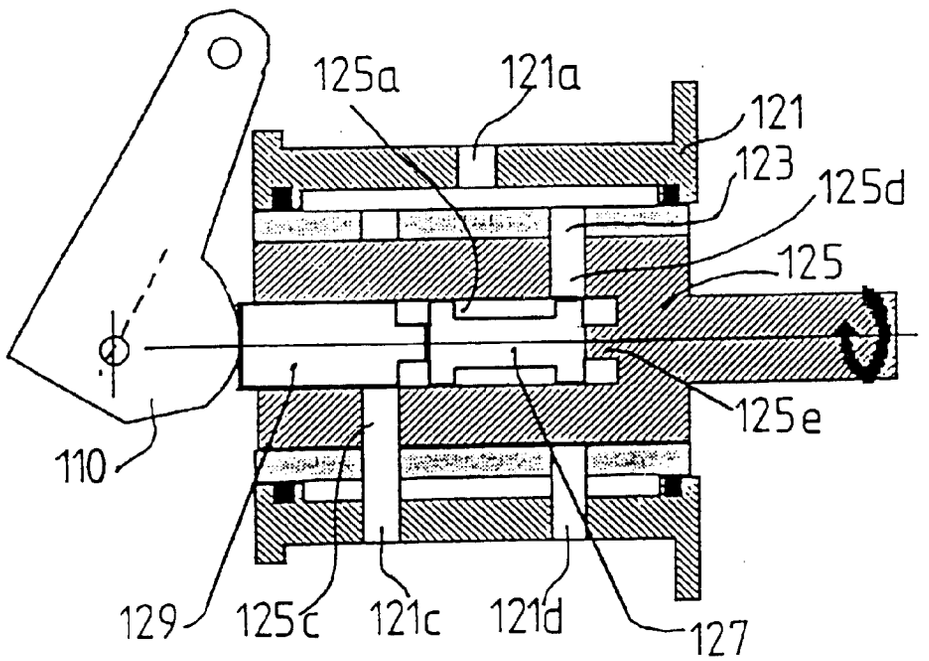

125a
121a
121
123
125d
125
125e
110
129
125c
121c
121d
127

Fig. 3

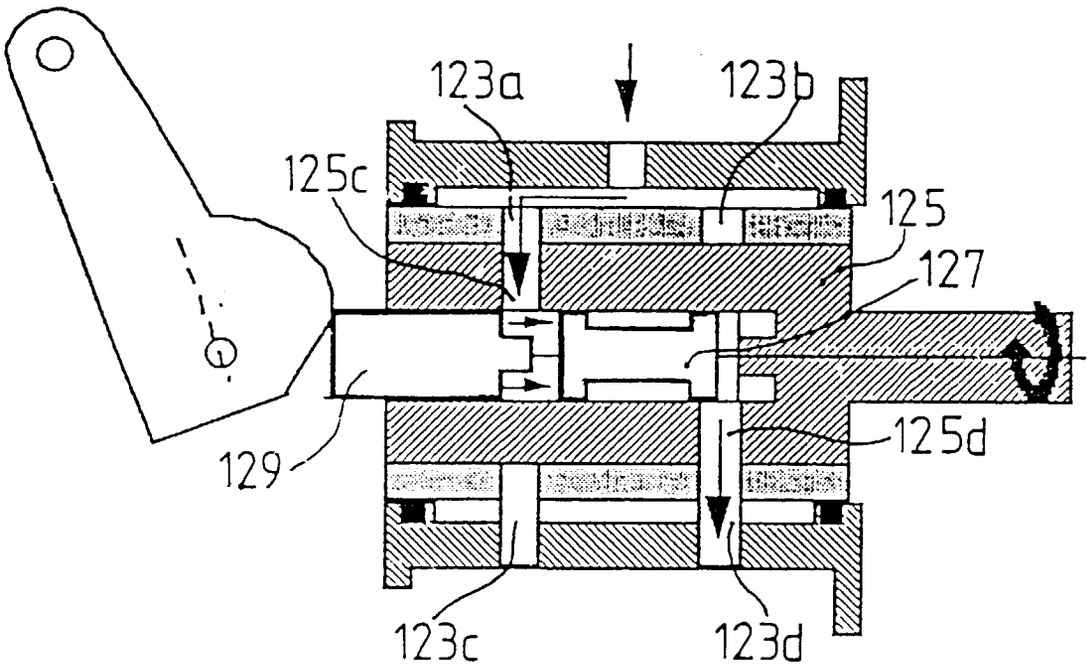

123a
123b
125c
125
127
129
125d
123c
123d

Fig. 4

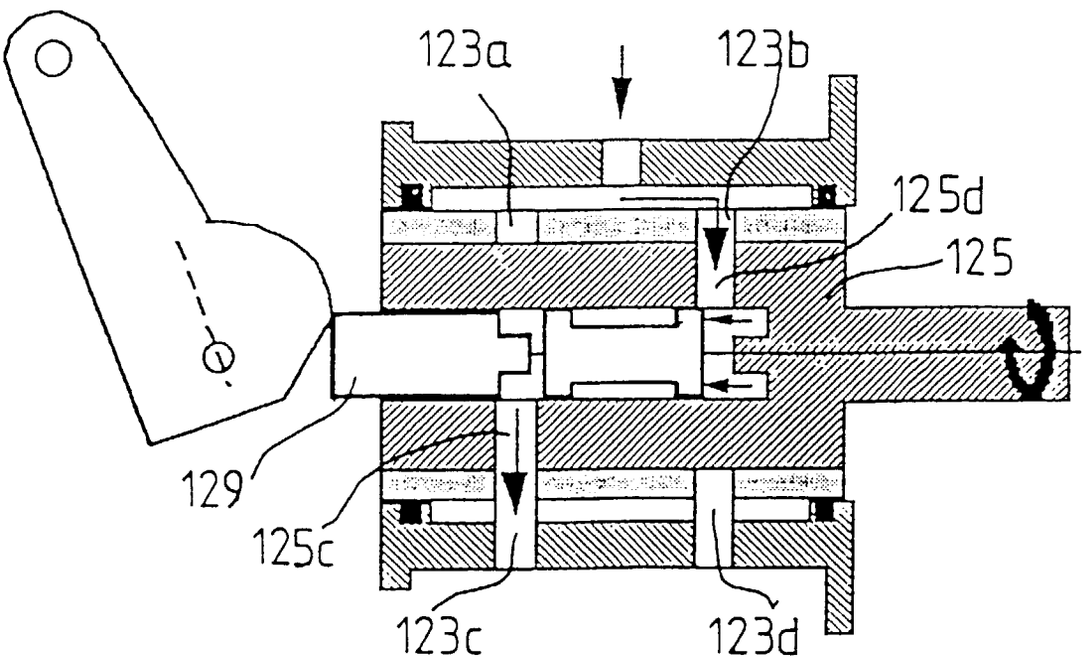

123a
123b
125d
125
129
125c
123c
123d

Fig. 5